6th Sense Transport

Sixth Sense Transport – A project investigating how smartphones can give users greater visibility of business and transport opportunities around them in space and time

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The 6th Sense Transport project is exploring the opportunities that can be provided by improving the temporal and spatial visibility of various transport, business and leisure options to people using Smartphones. Our interest is in understanding the extent to which behavioural change can be facilitated through the creation of a new form of 'transport network', based on extending social networking principles to transport users and their individual vehicles using smartphones. The project is being led by the University of Southampton and involves a collaboration between the University of Lancaster (School of Computing and Communications), Bournemouth University (International Centre for Tourism and Hospitality Research), University of Salford (College of Health and Social Care) and the University of Edinburgh (Architecture and Landscape Architecture). Sixth Sense Transport is a Digital Economy Research Project funded by the UK Research Councils.

Three apps have been written in iOS for the Apple iPhone platform and are being trialled:

6ST Campsite

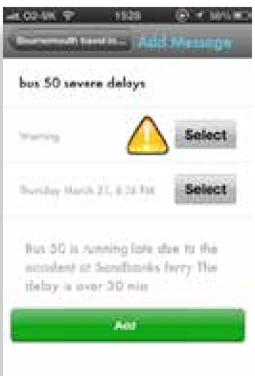
6STCampsite is designed to facilitate travel collaboration among campsite visitors. Visitors can use the app to join a unique social network comprising of visitors currently staying at their campsite. The app enables users to create locations on a map (Figure 1) to which they can tag messages such as advice on immediate travel conditions (Figure 2) and suggesting opportunities for leisure visits close to the campsite to reduce travel distances. The map view also visualises the movements of participants through the use of a heat map (Figure 1). Users can post and accept travel-related requests, such as lift-share (Figure 3) and shopping requests. It contributes to more effective use of local transport resources and visualises shared travel opportunities to campsite visitors to avoid unnecessary car journeys through collaboration. The app has attracted interest from village communities keen to improve transport accessibility in rural contexts. This led to the development of 6ST Travel, a similar app without the obvious tourism components.

Trials have taken place at in the tourism domain at Tom's Field Campsite, Dorset and with village communities at Maiden Newton, Dorset and Martock, Somerset. These have demonstrated the viability of the concept. Key findings include:

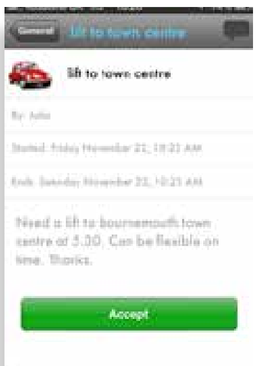
- Large groups with strong social ties were inhibited from engagement with the app at the campsite. Those with a large network of strong social ties were already engaged in collaborative travel to some degree. These groups had less need for the app. On-going analysis is exploring the role of social ties and the significance of tie relationships to travel collaboration using mobile media.
- In all trials there were more offers of help, i.e. lift offers or offers to collect shopping, than requests for help. The majority of users had cars and felt no need to ask for help, but users also felt some discomfort in asking for help. There was a desire to help others, but less desire to give up the 'bubble' of personal car use that provides personal flexibility.
- Tourists are much more inclined to share travel information compared to users in their day-to-day life which reflects the less time-constrained context.
- General reasons for lack of app use revolved around: lack of time; ability to make commitments; loss of flexibility; and technological barriers.

For more details visit: *http://www.sixthsensetransport.com/mobile-apps/6stcampsite/*

◀ Figure 1: Map view

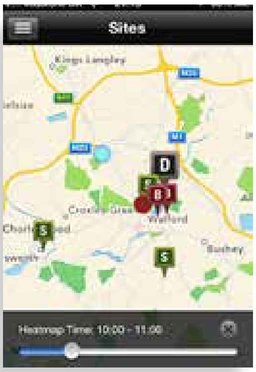


◀ Figure 2. Screen shot of travel information message



◀ Figure 3. Screen shot of lift request

◀ Figure 4. The main screen view of shops (S) and banks (B) and drivers (D) in the network. Each asset pin is interactive when touched.



◀ Figure 5. The driver location heat map (areas of higher intensity are coloured red, moving through green to blue, indicating lower intensity visitation)

◀ Figure 6. An example of a driver information bulletin board showing messages posted to the driver from shops.

6ST Oxfam

6ST Oxfam involves giving collection/delivery vehicles, shops and clothing/book banks the properties of a channel within a social network. This enables them to transmit data about their status, receive data about possible opportunities and carry information for others in the network, so enabling better transport and stock management decisions to be made. The infrastructure and drivers are represented in the app as a series of interactive pins, through which the transactions and messages are accessed by users (Figure 4).

The app allows Oxfam staff to visualise i) where drivers are at any time, and where they should be in the immediate future that day using historic geo-trace data (Figure 5); ii) current bank fill rates (%) based on Smartbin data (if sensors are fitted into the banks) or the last reported driver reading, and historic fill trends; iii) the fill rate of Oxfam vehicles in the area and current job status. The number of stock units to be moved each day (cascade and/or redundant stock) are recorded and the members of the community communicate via a messaging platform (Figure 6) which also pushes notifications out to members when transactions are undertaken.

Three-month trials have taken place across three different communities of users in the Oxfam network i) a driver, area manager and three shop managers in Hertfordshire ii) a driver, area manager and depot manager in Dorset iii) two drivers, an area manager and six shop managers in Cambridgeshire. Key findings include:

- In relation to donation bank management, the instant feedback provided to the community by the app enabled the area and shop managers to better evaluate site performance and make changes (e.g. round order, site visit frequency or longer-term bank placement strategy).
- Observed dwell times differed significantly between sites with banks at supermarket sites generally yielding more donations and taking more service time. The data emanating from the app was used by the area managers to re-assess and alter the order of the rounds and the frequency of some collections.
- Between the 3/6/13 and 3/9/13, 407 messages were sent between the members of the Cambridgeshire community relating to stock requests, information and queries. Of these, 44% were sent outside working hours, primarily in the evening showing that the most effective time for communication and arranging transactions was often not during work time.
- Results from interviews suggested that the app could be an instrumental tool for initiating transactions and helping the community understand how time was used in the business but that it would very much operate as a 'complementary' medium alongside telephone, email and other social media.
- Key problems experienced were poor 3G connection across the mobile networks in certain parts of the trial areas; a lack of time to respond to messages.

For more details visit: *http://www.sixthsensetransport.com/mobile-apps/6stoxfam/*

6ST Walking School Bus

Aimed at facilitating uptake of active transportation in primary schools, the 6ST Walking School Bus app is designed to increase the convenience of sustainable journeys to school from both the perspective of families and schools.

Traditionally, Walking School Buses (WSBs) are run without technology, and involve children walking together to school as a group supervised by a coordinator, usually an adult. In contrast, Smartphone enabled WSBs exploit real-time information to enable families to visually track the WSB (Figure 7) - represented as an icon on the screen - as it departs from its starting point, travels along designated stops and reaches the destination at the school. Families get a real-time estimate of the WSBs arrival time at their chosen stop and a visualisation of when it arrives at the school.

▲ Figure 7. Family view of progression of the Walking School Bus

From a technology perspective, the App is compatible for all iOS devices up from version 5.0+. Lancaster University hosts the centralised web service on a virtual machine cluster. The application downloads the pre-established pickup points and displays it to the user. It then uses the Google Maps Directions Service to create a route for the user. The WSB coordinator uses their application to push their location to a central web service every five seconds. The web service then queries the Google Maps Directions service to retrieve real-time prediction information for the user. This web service then disseminates »

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▶ Figure 8. Children monitoring the App under the supervision of the Walking School Bus Coordinator

this geo-location and prediction information to all other parent devices. The application can also be used by parents to add their children to the WSB. The child's information is anonymised, encrypted and sent to the web service. This can then be downloaded by the coordinator to view the children they need to pick-up at each stop (Figure 8).

A series of research studies and usability trials have been undertaken at five primary schools in Greater Manchester and North West England, and supported by an award-winning[1] partnership between the University of Salford, Lancaster University and Transport for Greater Manchester and district authorities. The key outcomes so far include:

- Acceptance of the concept by decision-makers (parents, headteachers, WSB coordinators)
- In the context of single one day trials, 32 parents involved in either 'experimental' or 'control' groups assessed the quality of their waiting experience both quantitatively and qualitatively. An initial outcome is no adverse impact on their waiting experience with 13/17 users reporting positive feedback, particularly about 'cutting down waiting time'.
- There is ongoing analysis of user 'time typologies' to determine any further customization that can be achieved.

For more details visit *http://www.sixthsensetransport.com/about/schools-case-study/* ◆

1. University of Salford in conjunction with Lancaster University were awarded a Modeshift Partnership Award, 2013.

Using remote monitoring data for collection scheduling

Results from the Oxfam demonstration

Authors: Fraser McLeod and Tom Cherrett, Transportation Research Group, University of Southampton

In the ITS(UK), Autumn/Winter 2012 review we introduced the concept and theoretical benefits of using remote monitoring sensors installed in waste and recycling containers, to enable more efficient collection schedules to be devised. In this article we move from theory to practice by presenting the results and experiences gained by Oxfam and the University of Southampton from a live demonstration of the technology and supporting decision-making systems that took place over 36 working days in May-July 2013. This research was made possible through the EU-funded Straightsol project (*www.straightsol.eu*) and the Sixth Sense Transport (*www.sixthsensetransport.com*) project funded by the RCUK Digital Economy Programme.

Oxfam uses more than 650 clothing and book banks across the UK to receive donations of unwanted goods from the general public. These are typically located in supermarket and public car parks or at recycling centres. Remote monitoring of donation banks is of interest to Oxfam not only for collection vehicle scheduling purposes but also for analysing bank performance, identifying possible instances of theft and allowing greater visibility of fill rates, long-term, for prediction purposes. For example, the data can be used to indicate whether certain types of site or geographical location generate more stock than others with the goal of improving bank placement strategy.

▲ Figure 1. Components of the operations (Images courtesy of Oxfam and Smartbin)

The demonstration

The demonstration involved up to six collection vehicles used each working day (Monday to Friday), based at Oxfam's Milton Keynes depot, servicing 56 bank sites and 68 Oxfam shops, with unsold items from the shops and the donated goods from the banks being taken to the depot for onward reuse or recycling. Ideally, all banks would have been monitored but, due to limited sensor availability, sensors were installed in 40 banks at 21 different sites, these sites either being chosen for their relative remoteness from the depot (do not want to visit too often to avoid wasted mileage) or as they had high yields (do not want to visit too late to avoid overflowing banks). The infra-red sensor was installed on the underside of the bank roof and measured the distance to the pile of goods below, from which a percentage fill level was derived. Sensors transmitted their fill level status twice a day, using an internal GSM antenna, with the data being held ❯❯

▲ Figure 2 The distribution area

on a central webserver hosted by the sensor supplier. The fill levels could also be viewed through a smartphone app developed as part of the Sixth Sense Transport project.

Before the introduction of remote monitoring, Oxfam used essentially fixed vehicle rounds with some small adjustments made to accommodate any additional jobs to be done. During the demonstration, visits to the shops were kept on their fixed collection days (between one to three visits per week) but visits to banks were decided 24 hours in advance depending on how full the banks were, with a minimum site collection requirement of 50% being used, that is to say, a site would not be visited unless its banks were, collectively, at least 50% full, as determined from the remote monitoring data, where available, or estimated based on historical bank yield records.

> The drivers were, on the whole, positive about the changes made.

A vehicle routing and scheduling algorithm was developed by the University of Southampton and used in the demonstration to suggest vehicle routes for the next day of operation based on the latest bank fill levels. This algorithm only took a few minutes to run on a desktop PC. The suggested routes were examined by Oxfam's transport manager each morning, with some adjustments being made manually, as seen fit, prior to implementation. Reasons for adjusting the routes included: concerns about shop time windows being missed if, for example, the vehicle was delayed in traffic; balancing of workloads between the drivers and crew involved across the working week; unavailability of a vehicle or driver on a particular day; preferring to delay or bring forward a collection; and inclusion of ad hoc work. These adjustments illustrated the need to retain the human knowledge and expertise, as it is very difficult, if not impossible, to design automated vehicle routes and schedules able to consider all possible operating scenarios. On the whole, though, these adjustments were relatively minor (e.g. sometimes reversing a round order) and Oxfam's transport manager liked and implemented the majority of the routes suggested by the algorithm.

Results

Vehicle rounds before and during the demonstration were compared in terms of numbers of banks visits, reports of full banks, vehicle mileages, round times and CO2 emissions. It was observed that:

- The total number of bank visits reduced overall by 28%, suggesting that some banks were previously being over-serviced.
- The numbers of banks reported (e.g. by members of the public or supermarket managers) as being full and in need of urgent collection were similar before and during the

▼ Figure 3: Estimated round distance savings

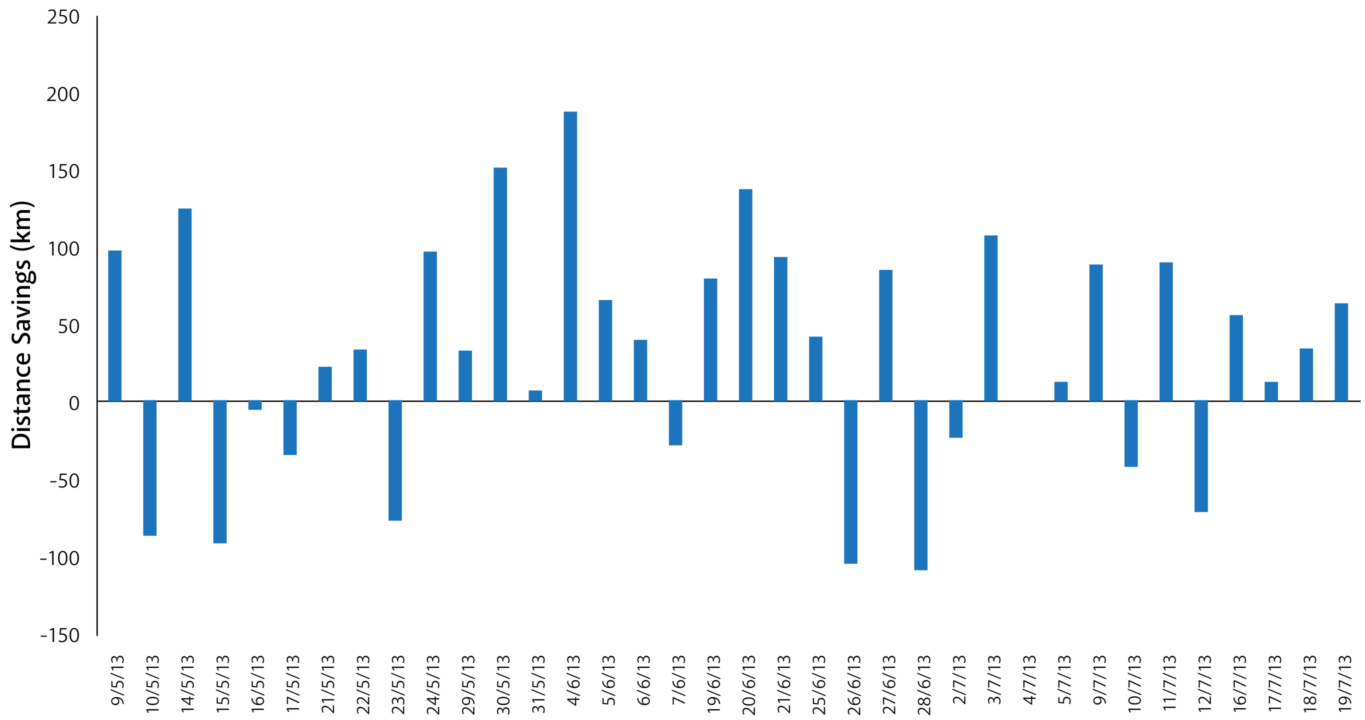

Image: Dogbomb

demonstration (1.2 per week before and 1.3 per week during), so there was no suggestion that the new operating procedures had reduced service levels.

- The total estimated mileage savings over all 36 days was 1159km (720 miles), an average of 32km (20 miles) per day across the vehicle fleet and a percentage savings of 3.2% (total distance in 'before' case = 35,919km). On the majority of days (Figure 3) total round distance was reduced due to reductions in numbers of bank visits made; the greatest savings on one day was 191km (119 miles) on Tuesday 4 June, where the number of bank visits was reduced from 21 to 12. Mileage increases of up to 110km (68 miles) were observed on some days mainly due to the inclusion of one or more bank visits to locations that did not fit onto any of the vehicle rounds well, as they were in different geographical areas. Some of these increases could perhaps have been avoided or reduced by delaying or bringing forward the collection.
- Time savings were gained not only due to the observed vehicle mileage savings but also due to a reduction in the total amount of time spent at banks. The total estimated time savings over all 36 days was 1152 minutes, an average of 32 minutes per day across the vehicle fleet and a reduction of 2.8% (total time taken in 'before' case = 679 hours).
- Based on an assumed average emissions factor of 400g/km, the total vehicle mileage savings of 1159km converted to an estimated CO_2 savings of 464kg.

Other considerations

The impacts of the new operating procedures on Oxfam staff were gauged from interviews with the Oxfam transport manager and with three of the drivers who undertook the collections. The main drawback as far as the manager was concerned was the additional amount of time (around two hours) required each day to decide on the routes to implement, to ensure that all shop and bank keys were with the correct drivers and to inform drivers and other staff (responsible for loading vehicles with items to be delivered to shops) of the vehicle itineraries. However, the transport manager liked the flexibility of the new rounds which made it easier to accommodate additional tasks and/or offer additional shop collections, if desired by shop managers. The drivers were, on the whole, positive about the changes made, with comments received including: "I sometimes finished work an hour early"; "Nearly all banks were at least 60% full when I visited"; "There was a better division of labour"; and "The technology prevents (other) drivers from only partly emptying a bank". The main dislike for the drivers was the fact that they sometimes had to go out of their way to visit a bank which had been rescheduled, corresponding to the days on which additional mileage was observed (Figure 3).

Conclusions

The time and distance savings (around 3%) were relatively modest here due, mainly, to the requirement to visit shops on fixed days, which severely limits the opportunities for altering the vehicle rounds substantially. Performance gains would likely be much higher in other application areas, such as collections from waste oil containers or from bottle banks, where these collections are not combined with other fixed work. Indeed previous studies have suggested typical savings of around 25%. In theory, Oxfam shops could be visited on a more dynamic and variable basis, which would avoid this problem; however, this does not seem likely to happen in practice as it would be difficult to manage given the fact that shops use large numbers of volunteer staff with varying levels of experience and ability. A separate article considers how the Oxfam community of shop managers, area managers, transport managers and drivers may benefit from shared information, including the bank status data used here. ◆

Image: Martin Pettit